ESR 13

Fiber-laser-pumped, continuous-wave, mid-infrared optical parametric oscillators based on new nonlinear materials

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MOTIVATION

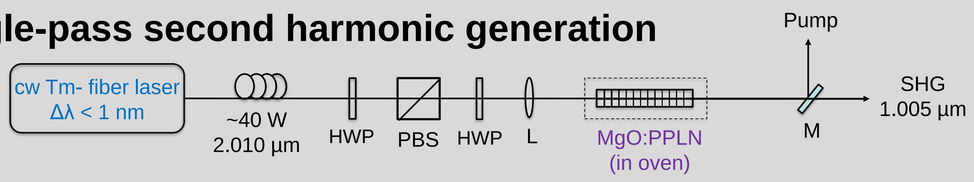
Mid-infrared (IR) tunable coherent radiation sources at wavelengths >3 μm, which are widely used in environmental monitoring, medical diagnostics, and spectroscopy have been an object of growing scientific interest since last few years. Continuous-wave optical parametric oscillators are suitable candidates to achieve high efficiency, high stability and narrow linewidth output in this mid-IR regime. The field is becoming more attractive due to development of new quasi-phase-matched nonlinear optical materials such as orientation-patterned gallium arsenide (OP-GaAs) and orientation-patterned gallium phosphide (OP-GaP), having transparency at wavelengths >5 μm.

GOAL

The primary aim is to develop a new generation of mid-IR radiation source in 3-4.5 μm spectral range using well studied MgO:PPLN crystal, providing high optical powers and wide wavelength coverage in cw operating domain. Subsequently tunable sources from 4-10 μm wavelength will be demonstrated using new NLO crystals such as OP-GaAs and OP-GaP. These materials are considered ideal for mid-IR generation as they have broad transparency ranges and large nonlinear coefficients.

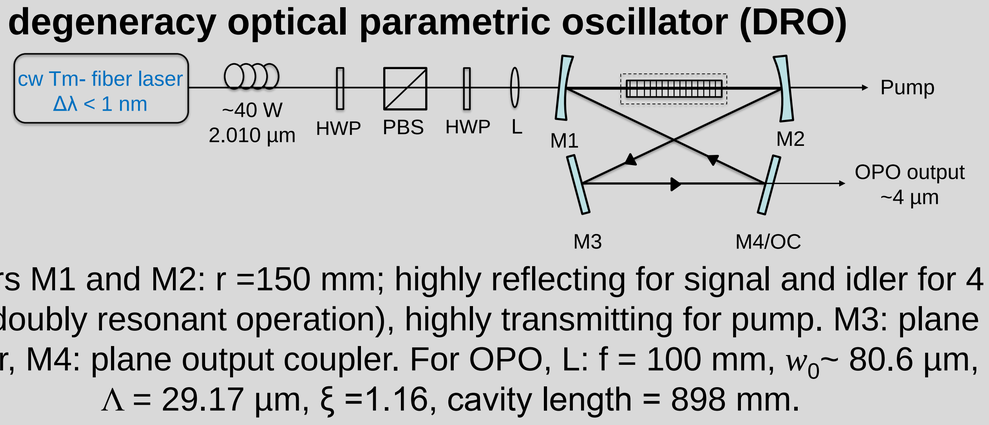
EXPERIMENTAL SETUP

Single-pass second harmonic generation



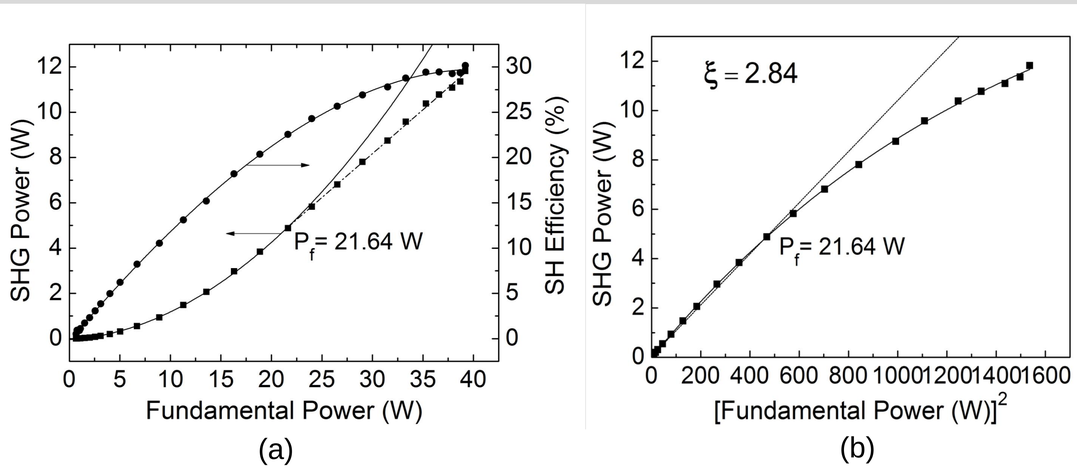
The fundamental beam is focused to a measured beam waist radius w_0~ 51.5 μm at the center of 50-mm-long crystal with grating period Λ = 30 μm (focusing parameter ξ = 2.84) using lens L: f =150 mm.
HWP = half-wave plate, PBS: polarising beam splitter, M: dichroic mirror.

Near degeneracy optical parametric oscillator (DRO)



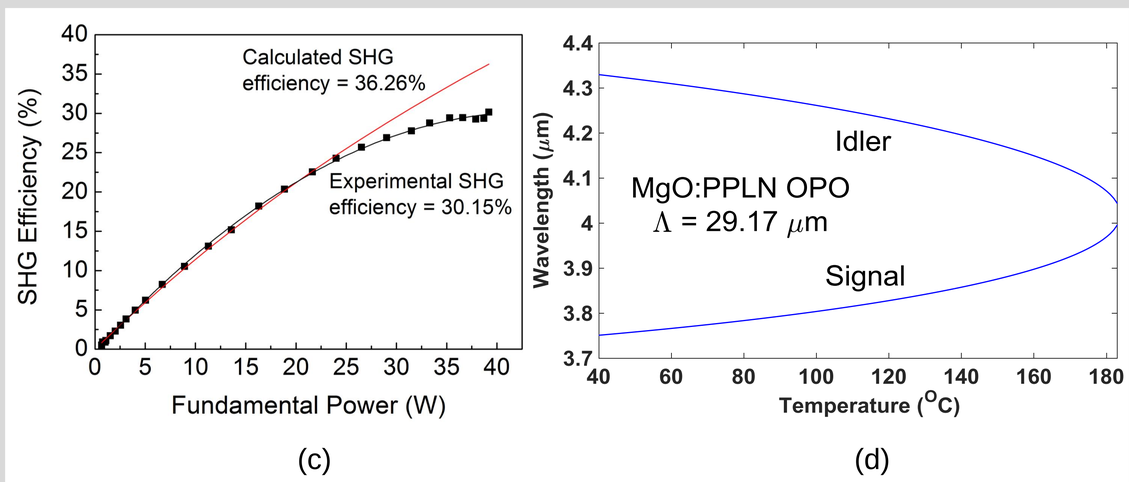
Mirrors M1 and M2: r =150 mm; highly reflecting for signal and idler for 4 μm (doubly resonant operation), highly transmitting for pump. M3: plane mirror, M4: plane output coupler. For OPO, L: f = 100 mm, w_0~ 80.6 μm, Λ = 29.17 μm, ξ =1.16, cavity length = 898 mm.

RESULTS OBTAINED SO FAR



(a) Dependence of measured SHG power and corresponding conversion efficiency on the incident fundamental power
(b) Variation of the measured SHG power with square of the fundamental power

Nonlinear coefficient of MgO:PPLN crystal is calculated using slope of graph (b), d_{eff} = 7.47 pm/V



(c) Theoretically calculated and experimentally obtained SHG conversion efficiency vs fundamental power.
(d) Temperature tuning curve of MgO:PPLN OPO with grating period 29.17 μm.

Specific applications of 1.005 μm source:

1. In the study of energy dynamics of light-harvesting protein-pigment complexes [1]
2. In the study of photovoltaics structure [2]

PLANNED SECONDMENTS

1. DTU - February 2017 - 1 month
• Hands-on experience in up-conversion module building with Dr. Ajanta Barh to gain expertise in the field.
• Project on fire alarm in collaboration with Danish Institute of Fire and Security Technology (DBI), by combining cw OPO setup with up-conversion system for detection.

2. DTU - June 2017 - 1 month
•Project progress depending on the first secondment stay.
•Projects on hyper-spectral imaging and trace gas detection using cw OPO + up-conversion setup.

3. IRS - October 2017 - 1 month

PUBLICATION PROSPECTS

- "Novel continuous-wave mid-infrared source, tunable across 3-5 μm based on thulium fiber laser."
- "Mid-infrared upconversion imaging using continuous-wave optical parametric oscillator."

REFERENCES

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[2] Wang et al., IEEE J. Phot., 5, 1943-0655 (2013)

ACKNOWLEDGMENTS

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